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Abstracts

Evolution and Development

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How many steps to build animals?

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All theories of the origin of the Metazoa begin with unicellular eukaryotes and end with the known phyla. Although the endpoints are thus fixed, the respective trajectories (pathways) of various theories through genotypic and phenotypic space do not agree. Using a formalization developed by Stadler et al. (2001), I present an analysis of the problem of the origin of metazoan form that characterizes the evolutionary problem to be solved in terms of finding pathways on which natural selection can act.

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Development of mandibular and clavicular secondary cartilage is strongly influenced by mechanical cues from the skeletal musculature

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We employed Myf5−/−:MyoD−/− fetuses that completely lacked striated myoblasts and myofibers to study bone development in the absence of mechanical stimuli from the musculature. We concentrated on development of the mandibles and clavicles. More specifically, we asked (a) how the secondary cartilage formation and other osteogenic events are initiated and maintained in the absence of the mechanical stimuli from the skeletal muscle and (b) to what extent and how the size and shape of the mandibles and clavicles is altered in the absence of the stimuli from the skeletal muscle. We employed morphometry and morphology at different embryonic stages and compared bone development in Myf5−/−:MyoD−/− and control fetuses. Our findings can be summarized as follows: (a) the mutant mandibles and clavicles had dramatically altered shape and size, (b) these effects varied depending on the bone (e.g., clavicles being more dependent than mandibles) and even within the same bone (e.g., different processes of the mandible), and (c) we further supported the notion that mammalian clavicles arise under different influences from that that initiate the wishbone in birds. Together, our data show that the development of secondary cartilage, and in turn the development of the final shape and size of the bones, is strongly influenced by mechanical cues from the skeletal musculature. Supported by NSHRF to BK.

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Lamprey type II collagen and Sox9 reveal an ancient origin of the vertebrate collagenous skeleton

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Type II collagen is the major cartilage matrix protein in the jawed vertebrate skeleton. Lampreys and hagfishes, by contrast, are thought to have non-collagenous cartilage. This difference in skeletal structure has led to the hypothesis that the vertebrate common ancestor had a non-collagenous skeleton, with type II collagen becoming the predominant cartilage matrix protein after the divergence of jawless fish from the jawed vertebrates, approximately 500 million years ago. Here, we report that lampreys have two type II collagen (Col2α1) genes that are expressed during development of the cartilaginous skeleton. We also demonstrate that the adult lamprey skeleton is rich in Col2α1 protein. Furthermore, we have isolated a lamprey orthologue of Sox9, a direct transcriptional regulator of Col2α1 in jawed vertebrates, and show that it is co-expressed with both Col2α1 genes during skeletal development. These results reveal that the genetic pathway for chondrogenesis in lampreys and gnathostomes is conserved through the activation of cartilage matrix molecules and suggest that a collagenous skeleton evolved surprisingly early in vertebrate evolution.

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Genetic stabilization of vertebrate bilateral limb symmetry as an example of cryptic polarity

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